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ROCK-BOLTING APPARATUS AND METHOD

Background of the Invention

This invention relates to a rock-bolting apparatus and method.

This invention has particular but not exclusive application to a rock-bolting apparatus and method for use in mine construction, and for illustrative purposes reference will be made to such application. However, it is to be understood that this invention could be used in other applications, such as general tunnel construction, underpinning and the like.

Prior Art

Underground mining of mineral ores, such as coal and hard and soft rock mining requires the 'development' of underground drives in the form of tunnels. In all hard-rock applications, drive development is achieved through a drilling, charging, blasting, and mucking cycle. In the drilling stage of the cycle, a pattern of holes is drilled into the blind end of the drive. The holes are generally parallel to the drive axis. Typically, holes are 2-4 metres deep.

In the charging stage, explosive is placed in the drilled holes and connected via a detonating arrangement. In the blasting stage the explosive is detonated, the resulting blast fracturing the solid rock. In the mucking stage a front-end loader digs the fractured rock and removes it for hoisting to the surface via skips. This development cycle is well understood and is currently the most cost effective means of developing drives in hard rock.

An unavoidable consequence of this proven method is rock fracture beyond the desired geometric shape of the tunnel cross-section. This rock fracturing can cause the tunnel roof or back and/or the drive's side walls to be unstable. Rock

fragments large and small can disengage from the back and sidewalls and fall under the influence of gravity. Particle size ranges from microscopic to cubic metres. Falling particle larger than a tennis ball can prove fatal to personnel.

To protect miners from larger falling particles, a rock bolting/meshing procedure is applied. The process requires drilling holes 2-4 metres long in the 'back' (walls and overhead), and holding square mesh, typically 50 mm x 50 mm to 150 mm x 150 mm apertures, against the 'back'. Rock bolts and retaining plates are inserted through the mesh and into the drilled holes. Larger particles are restrained from falling by the rock-bolts and smaller particles are retained or caught by the mesh.

Rock bolts come in various style and each style is available in a range of lengths. Common styles include the clip set type where long slotted tubes grip the drilled hole via radial springing action along the entire length of the bolt. These bolts rust away in time and jeopardize long term security. The wedge-lock type is a bolt with an expanding tip, the locking action being controlled by screwing action. The gripping is at the blind end of the hole only. These bolts also rust away in time and jeopardize long term security. Epoxy grouted systems utilize a two-pack epoxy sausage which is inserted into the drilled hole. The bolt is inserted via a rotating action which mixes the epoxy. Curing a rapid usually about 35-60 seconds. Grip is along the entire length of the bolt. These bolts resist corrosion. Cement grouted systems are also used.

Rock-bolting/meshing equipment comes in two broad groups, comprising purpose built drilling; bolting machines and adaptations of twin boom development heading 'jumbo' drills. The purpose built drilling, bolting machines generally feature

three parts, being a transport vehicle subassembly, a multi-axis support arm mounted thereon and a drilling and bolting mechanism on the support arm. The drilling and bolting mechanism contains many functions and is relatively heavy, both for robustness and to provide inertial stability. The multi-axis support arm, while capable of supporting the mechanism, tends to deflect, has low natural frequencies of bobbing up/down and back/forth and also has poor 'fine control'. The transport vehicle is rubber tyred, with articulated steering, diesel powered and with front jacks for vehicle stability while working.

In use, problems arise because of the physical properties of the freshly fractured rock surface. It is uneven and fractured, presenting a myriad of randomly oriented faces. Lighting from the vehicle throws this surface into stark black/white features where the operator cannot determine the inclination of faces to select a stable face for drilling.

Collaring is the step of the drill taking purchase and commencing the new hole and usually describes the first 0-20 mm of drilling. The drill head is a blunt steel arrangement with embedded tungsten carbide tips, air/water cooled and purged via a central hole along the drill steel. Cutting is by rotation and impact from the drill, typical drilling being at 1-2 metres per minute. When the blunt drill head strikes an angled rock face in attempting to collar a new hole, it cannot achieve penetration. The drill slides down the face until it finds purchase in the 'valley' between two intersecting planes of the rock faces. Collaring now proceeds as does the remainder of the hole drilling.

The drill bit, sliding down the rock face and into the 'valley' demands lateral compliance since the support arm's hydraulics have not yielded or adjusted.

Compliance is available from many sources including elastic bending of the drill steel, mechanical play or hackles in the drill steel/drill interface, the drill/drill slide interface and every other mechanical junction, deflection in the supporting arm, and deflection in the supporting vehicle.

The drill achieves a collared and drilled hole, albeit not precisely where the drill was aimed. Upon drill steel extraction form the new hole, the elastic compliance is released and the whole machine wobbles back and forth, finally settling with the drill steel axis no longer aligned with the freshly drilled hole. The mechanism now increments, removing the drill from the axis and replacing it with the bolt magazine and inserted. The bolt has little chance of finding the hole because the mechanical 'slop' (play, clearance, backlash) is endemic, with machine parts which are expected to operate reliably despite spending their lives in a shower of water, grit and falling rocks. The net effect is that the drill will often not be co-axial with the bolt. Rock fragments often fall from the 'back' around the freshly drilled hole to sit on the mesh, masking the hole. Attempting to insert an all metal bolt is normally unsuccessful. The machine operator then gets out of his protected cabin and walks under the unprotected, freshly fractured, freshly drilled ground to try and find the offset error between where the hole axis lies and where the bolt axis lies. This is the most dangerous time with a high risk of falling rock causing death or injury. The operator goes back to his machine and tries to remember the direction and distance of the offset and, using an arm with poor 'fine control', attempts to adjust for the error. There are often several attempts to be made to adjust for bolt insertion. With epoxy grouted bolts, these aiming problems can see the two-part epoxy sausage bursting,

covering the drilled/bolting mechanism with rapidly setting epoxy, which can disable the mechanism.

The twin boom jumbo solution goes part way toward alleviating the inherent difficulties and dangers associated with meshing drives. The key advantage of the twin boom jumbo is that only one piece of equipment is required to a given drive heading. The miner can drill, blast and roof-bolt with the jumbo. In the jumbo roof bolting methods to date, bolt selection is limited to non-grouted bolts. For short-life development loadings into mass-blast steps area, this is not a problem. For long life drives eg. declines, this is be a problem because of the aforementioned bolt corrosion. Generally, the right boom carries the mesh sheet up to the back, hanging from the drill steel. The left boom carries the bolt and inserter in the form of the left boom drill drive, and orients the mesh against the back. The hole is drilled via the right arm. The right arm then holds the mesh, away from the freshly drilled hole. The left arm travels and, being aligned by eye from the machine, inserts the bolt into the freshly drilled hole. Once one bolt is inserted, the mesh sheet is self supporting. It is necessary for both jumbo drills to be aligned prior to drilling to ensure the axes of the drilled and bolting mechanism were basically parallel. With high operator skill levels, this method, used in ground with reasonable surfaces, proves reasonably efficient.

The major disadvantages are the high operator skill required, and the bolt type limitations. The major advantages are that only one piece of equipment is required.

The present invention in one aspect resides broadly in rock-bolting apparatus including carriage means, boom means mounted on said carriage means and adapted to extend to engage opposed wall portions of a drive to be secured, drilling

means associated with one end of said boom means, and rock bolt installation means associated with said boom means.

The carriage means may take any form usual in providing underground rock mining equipment. For example, the carriage means may comprise diesel, electric or hydraulically operated plant, mounted for movement on any suitable undercarriage such as tracks, wheels or rails.

The boom means may comprise a fixed length boom having extending elements mounted thereon or may comprise a telescoping arrangement. The extension of the boom is preferably hydraulic in operation. The boom may be configured to be movable in one or more of azimuth, elevation or slew by mountings comprising either fixed pivot and/or lost motion apparatus.

The carriage means preferably includes a rated safety cell or cage for the operator. The safety cell or cage may be configured to slew with the boom, whereby the operator may observe the operation of the apparatus from a fixed perspective.

The boom is preferably configured whereby the operator may perform the drilling operation from a position where the safety cell or cage is located beneath a prior-stabilized portion of the drive or tunnel.

The drilling means may be mounted on or within the boom. For example, the drilling means may be mounted within a boom assembly whereby the drilling rod thereof extends through one or more of means provided for engagement of the boom assembly with the wall of the drive. The means providing engagement of the boom assembly with the drive wall may take any suitable form. For example the engagement means may comprise one or more engagement spikes associated with

the respective ends of the extendible boom means. Preferably, at the drilling end of the boom there is provided an array of spikes about the drilling axis.

There may be provided a pilot guide means associated with the drilling means and adapted to provide an initial guide for the drilling rod to collar the hole. The pilot guide means may be selected to remain in position for one or more of the drilling, grouting and bolting functions of the apparatus. The pilot guide means may be selected to work in concert with, or in fact be, the means providing engagement with the drive wall. The pilot guide means may comprise a conical or other tapered solid section having a hole bored therethrough to admit the drill rod whereby the terminal minor section engages and stabilizes the collared hole for drilling and bolting, with or without grouting.

The rock bolt installation means associated with said boom means may take any suitable form and will generally be determined as to configuration by the boom arrangement and drill means arrangement. Preferably, the rock bolt installation means is mounted on the boom means and is configured to cooperate with the drill means by way of moving into index with the drilled hole as the drill means is moved out of index therewith. The rock bolt installation means mat be provided with a magazine containing a plurality of bolts such as a rotary magazine. Where requires the rock bolt installation means may also include a grouting sausage installation arrangement whereby a grout sausage may be inserted in the drilled hole ahead of bolt installation. The rock bolt installation means may be configured to apply rotation with insertion of the rock bolt, either during insertion or at the end of insertion, depending on the bolt type used.

The apparatus preferably includes a mesh supply and delivery means therefor whereby the drilling, meshing and bolting functions may each be addressed by the operator from the carriage safety cell or cage. For example there may be provided a spindle mounted mesh roll on an articulation capable of presenting and deploying the mesh ahead of the drilling program. The deployment may be in large areas, but it is preferred that deployment occurs progressively with rock bolt installation. The mesh may be deployed in panels as an alternative to a roll with cutter.

The apparatus may also include other functions such as descaling wherein an articulation means mounts a rock hammer to dislodge loose material from the drive walls ahead of meshing. The articulation means may be separate form the mesh supply and delivery means, and the boom means, or alternatively the articulation means may comprise an additional function of one or the other of the mesh supply and delivery means, and the boom means. In one embodiment of the present invention, the additional functionality is provided by a second drill, that may be used to drill ahead as well as a descaling implement. Preferably the descaling operation is conducted while the safety cell or cage is located under a supported portion of the drive.

In a further aspect this invention resides broadly in a method of securing the walls of a drive or the like and including the steps of providing carriage means adapted to be located within a supported portion of said drive and having boom means mounted on said carriage means, extending said boom means to engage opposed unsupported wall portions of said drive, drilling holes in one said unsupported wall portion with drilling means associated with said boom means, and installing rock bolts in said drilled holes with rock bolt installation means associated with said boom.

The invention will be further described with reference to the drawings illustrating a preferred embodiment of the present invention and wherein:

FIG. 1 is a perspective view of apparatus in accordance with the present invention in descaling use;

FIG. 2 is a perspective view of apparatus in accordance with the present invention in use;

FIG. 3 is a perspective detail view of apparatus in accordance with the present invention in use;

FIGs. 4 to 7 are progressive operation views of the detail of FIG. 3.

In the figures there is provided a diesel-powered carrier 10 having a mesh handling assembly 11 and a drilling/bolting assembly 12 mounted thereon. The mesh handling assembly 11 comprises a hydraulically operated rotating mount 13 to which is articulated a primary arm 14. The primary arm 14 articulates a hydraulically operable extending arm 15 having mounted at its outer end a coiled mesh reel 16 having associated therewith a deploying drive and cutter (not shown). The coiled mesh reel 16 is detachable to be stowed on the diesel powered carrier 10, whereupon a descaling hammer 18 may be mounted on the extending arm 15.

The drilling/bolting assembly 12 comprises a hydraulically operated rotating mount 17 to which is articulated a primary arm 20. The primary arm 20 articulates a hydraulically operable extending arm 21 having mounted thereon an articulated assembly carrier 22. The assembly carrier 22 forms an elongate housing for a hydraulically extendible telescopic brace 23 adapted to extend from one end of the assembly carrier 22. On the other end of the assembly carrier 22 is provided a drill assembly 24. The drill assembly 24 comprises a drill guide assembly 25 of conical

form having a guide bore 26 formed therein, the drill guide assembly being divided about its conical axis to form guide halves 27. The guide halves 27 are formed on struts 30 that are mounted in inclined bores on a guide carrier 31, whereby advancement of the struts 30 closes the guide halves 27 up to provide a drill guide in contact with a rock wall, and retraction of the struts 30 opens and retracts the guide halves 27 against the guide carrier 31. The guide carrier 31 has a bore 32 formed therein that is coaxial with the guide bore 26. A hydraulically operable drill 33 mounts a drill bit 34 coaxially with the guide bore 26 whereby the drill bit 34 may be advanced through the guide bore 26. A rotary magazine 35 is mounted on the assembly carrier 22 and carries several drill bits and rock bolts 36 which may be selectably moved into index with the axis of the guide bore 26. A grout delivery tube 37 is mounted on swinging clamps 40 whereby the grout deliver tube 37 may be moved in to and out of index with the guide bore 26. The drill bit 34 may be advanced to provide for insertion of the grout delivery tube 37 into a formed hole through the guide bore 26. The grout delivery tube 37 is supplied with grout composition or grout sausages through a flexible tube 41leading from the diesel powered carrier 10. A pair of spaced engagement spikes 42 are mounted on the assembly carrier 22 whereby they may be hydraulically extended into engagement with the rock face, the reactive force of engagement being countered by engagement of the hydraulically extendible telescopic brace 23 with the opposite face of the drive. The diesel powered carrier 10 supported on 4 corner mounted stabilizing jacks 43 to isolate the braced drilling/bolting assembly 12 from suspension compliance.

In use, the diesel powered carriage 10 is driven to the tunnel where the roof is to be secured; and parked under supported roof. The diesel powered carriage 10 is

stabilized via the 4 corner mounted stabilizing jacks 43. The mesh handling assembly 11 first mounts the descaling hammer and descales the 'back' (roof). During descaling all other mechanisms are retracted and protected under the previously supported roof.

The mesh handling assembly 11 then picks up the coiled mesh reel that is stored on the machine. The reel is stored in a position that makes it possible to reload it from the rear. The coiled mesh reel is fitted with a means of unreeling the coil and a means of cutting the mesh once installed. The unreeling can be accomplished by powering the central hub of the roll or by passing the mesh between rollers. The cutting of the mesh can be by a guillotine action or cutting wheel. The coil is unwound so that a small sheet of coil is covering the beginning of the area to secure.

The drilling/bolting assembly 12 is then offered up to the mesh for installation of the first bolt. To secure the mechanisms during drilling, grouting and bolting the apparatus uses the telescopic brace in opposition to the two extendible spikes to lock the mechanism against opposite sides of the tunnel. The procedure is to extend the conical guide and position it against the rock face where the next bolt is required. The two extendible spikes are then extended to engage the rock face. The drilling/bolting assembly 12 can be rotated to position the spikes where they can be well seated. The telescopic brace is then extended until it engages the opposite wall of the tunnel. The thrust from the telescopic brace is greater than the combined thrust of the two extendible spikes thus when full power is applied to all cylinders there is a net force seating the cone.

The drilling/bolting assembly 12 is now independent of the machine or machine arm flexibility and will remain as solidly positioned through the bolting cycle.

Once the drilling/bolting assembly 12 is positioned and secured for drilling as above the cone remains in contact with the rock. This provides an initial guide for the drill to prevent it from drifting and also secures the area around the hole. The cone then stays locked in position to provide a smooth transition for the epoxy, grout or bolt from the insertion mechanism into the hole. When the bolt is inserted into the hole and is being screwed or pushed in the cone retracts providing a clear path for the bolt capping plate.

Once the hole has been drilled the clamps swing the pipe to align it with the drill axis. The drill then engages the pipe and the clamps are released and retracted. The drill then extends without rotating inserting the pipe into the drilled hole. The rear of the pipe is connected via the flexible hose to a grout pump or an epoxy tube ejection unit. Epoxy tubes consist of a flexible plastic tube of hardener inside a flexible plastic tube of resin. These can be shot into the drilled hole through the pipe and interconnecting hose by compressed air. The operator places the epoxy tube into the ejection unit, which is accessible from the cockpit, and eject it once the pipe is extended into the hole. If grout were to be used the hose would be connected to a grout pump that the operator would control to fill the drilled hole once the pipe was inserted. The pipe would then be withdrawn leaving the epoxy tube or grout in the hole. The pipe and hose once retracted are re-clamped, disengaged from the drill and swung clear.

The bolt/drill magazine is deployed by the two rams with bar clamps on their end. These are retracted to clear the bars allowing the carousel to index into position.

The rams then extend and the end clamps clamp the bar or drill. The rams then extend pulling the bar/drill from its mount in the carousel and positioning it on the axis of the drill. The drill then engages the bolt/drill, the clamps release and retract, and the drill is free to extend and rotate as required.

It will of course be realised that while the above has been given by way of illustrative example of this invention, all such and other modifications and variations thereto as would be apparent to persons skilled in the art are deemed to fall within the broad scope and ambit of this invention as is herein set forth.

DATED THIS FIFTH DAY OF DECEMBER, 2000.

RUSSELL MINERAL EQUIPMENT PTY LTD

by

PIZZEYS

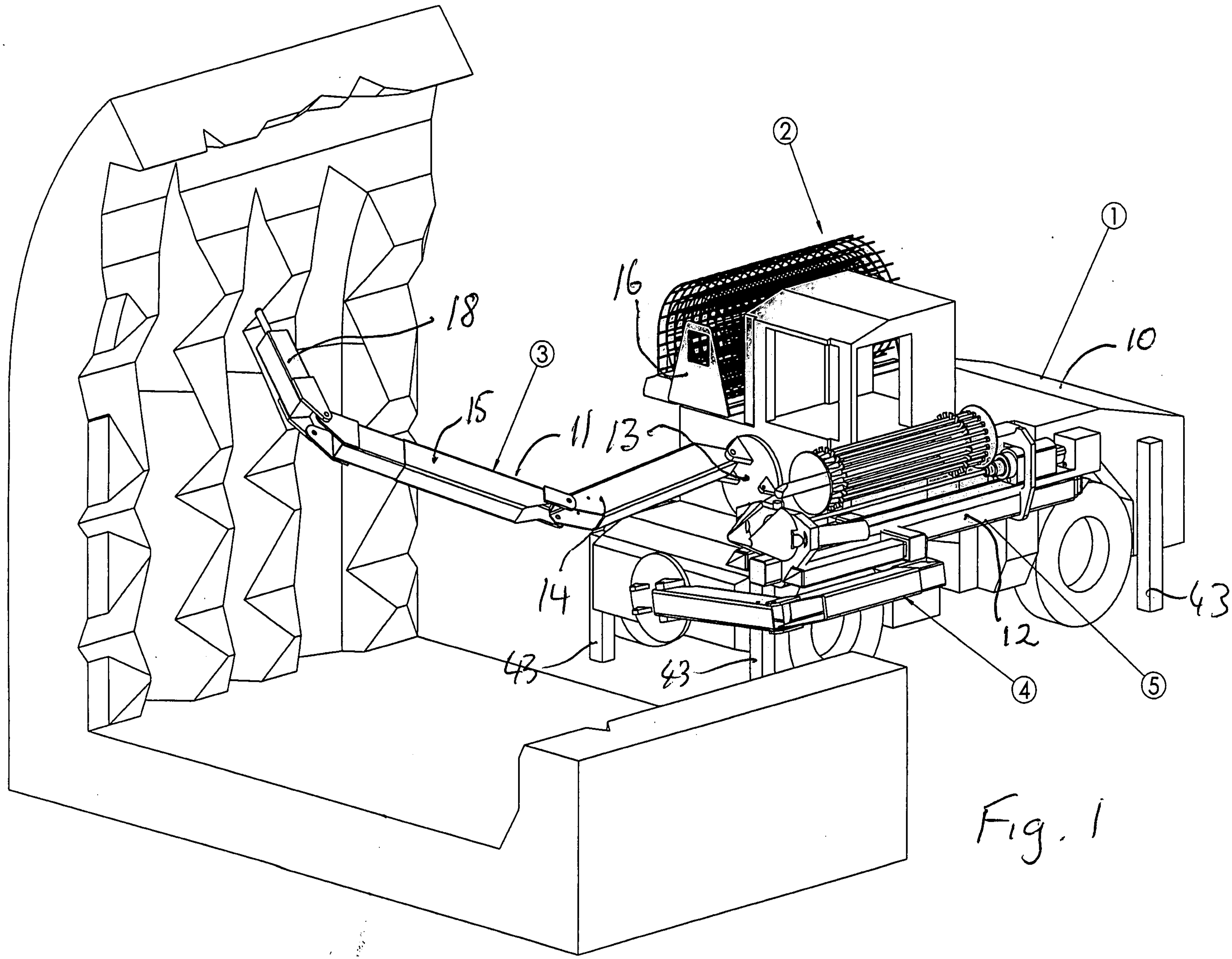


Fig. 1

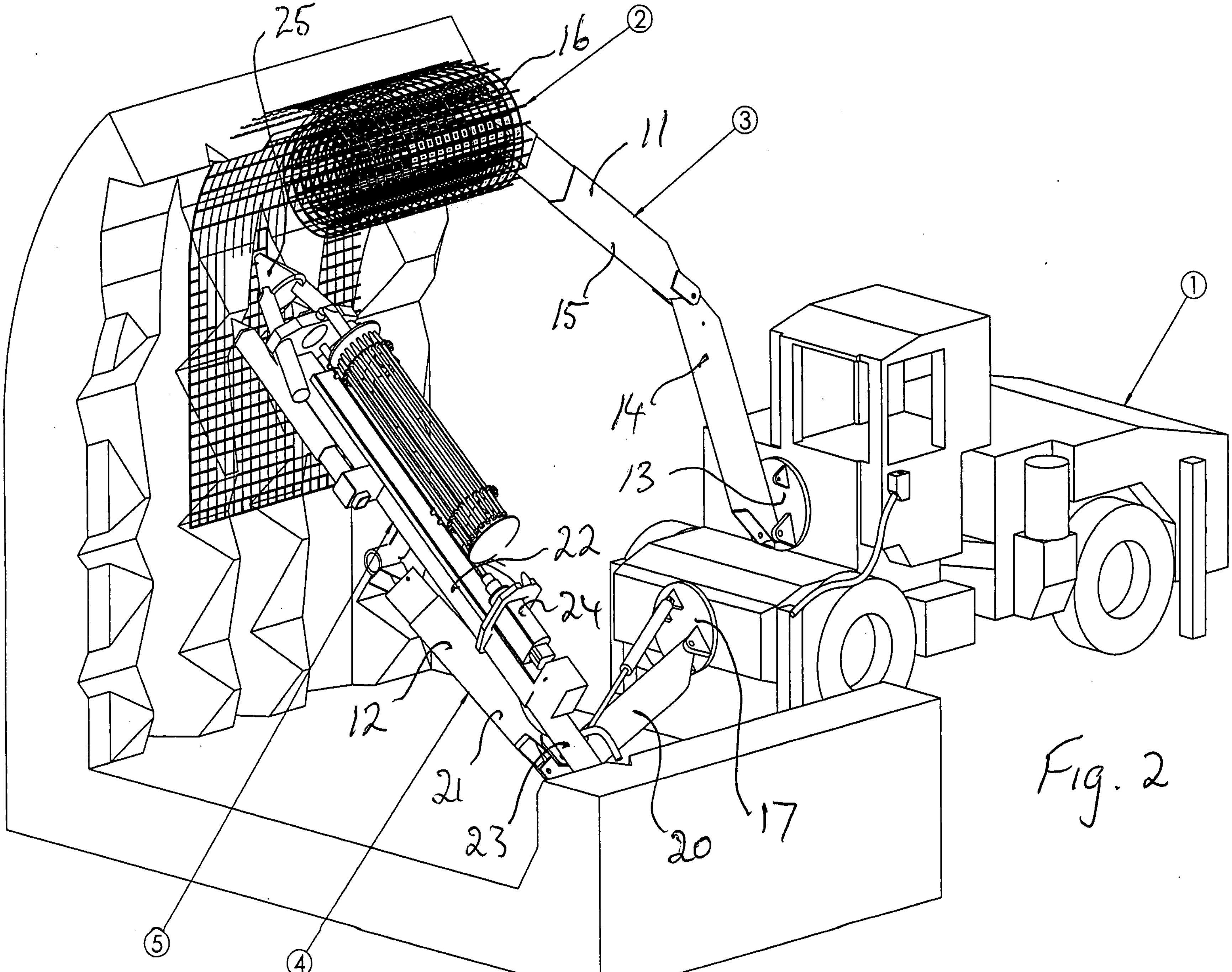


Fig. 2

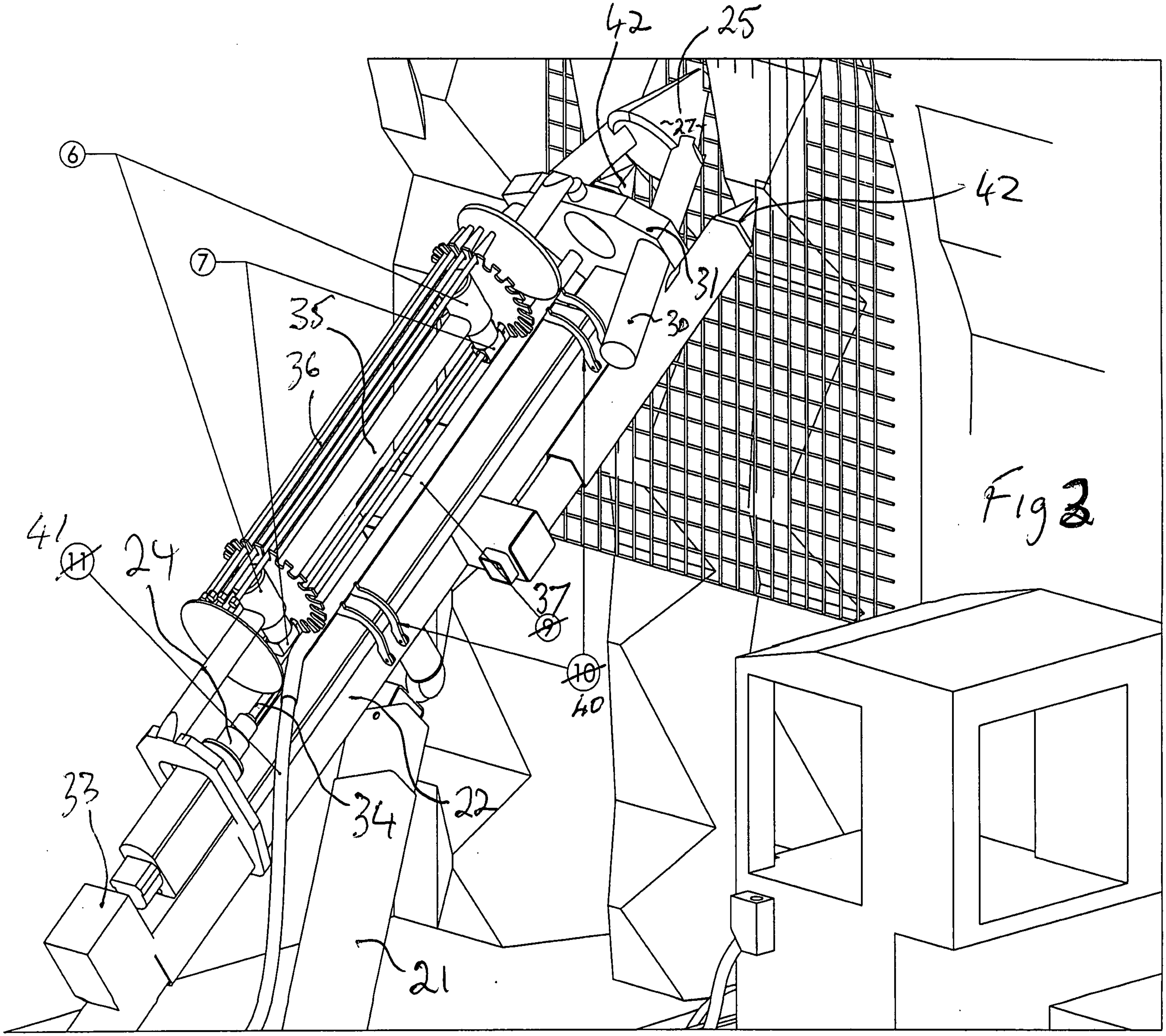
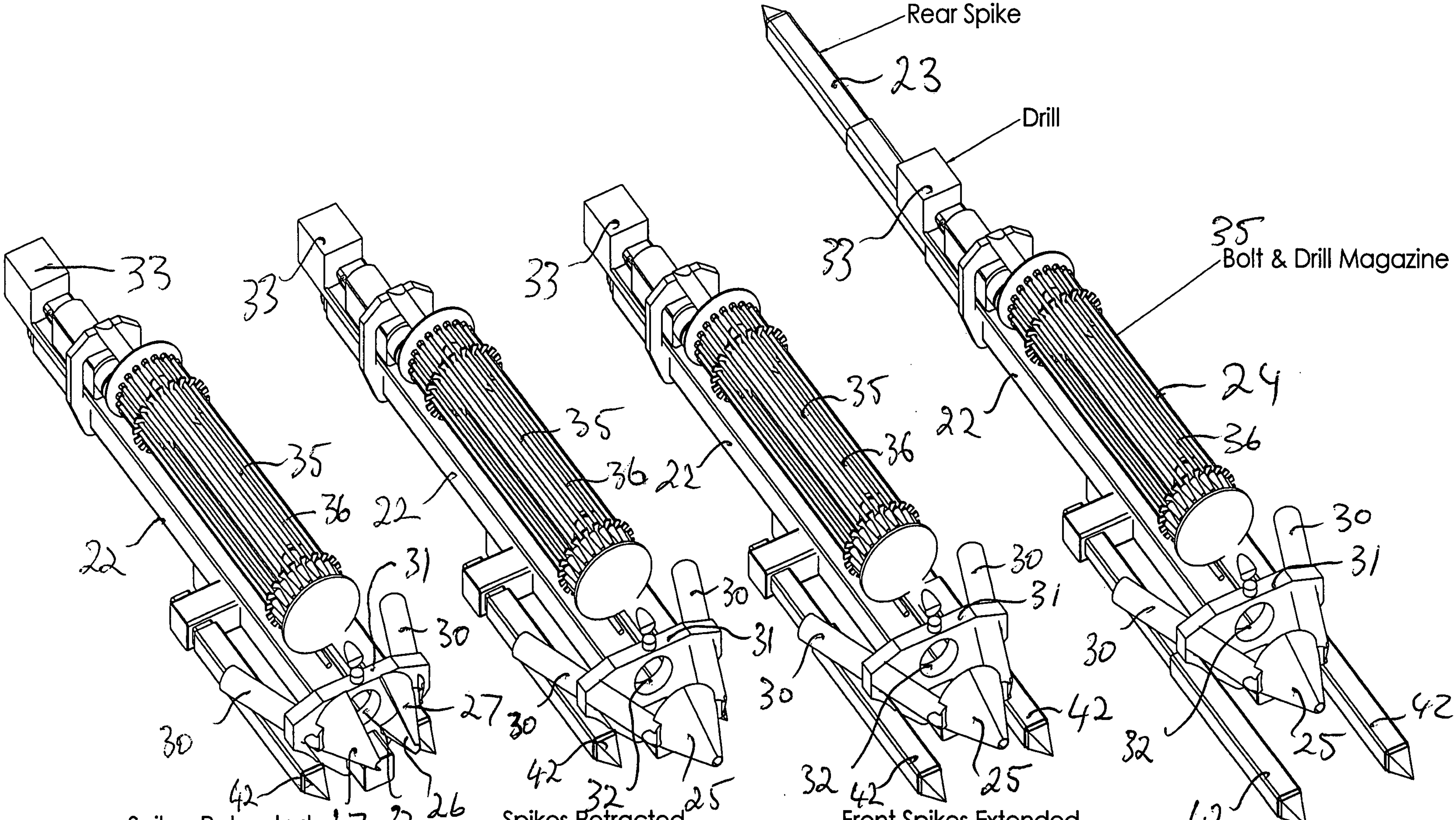


Fig 2

TRIDENT



Spikes Retracted
Cone Retracted and Open

Fig. 4

Spikes Retracted
Cone Extended and Closed

Fig. 5

Front Spikes Extended
Cone Extended and Closed

Fig. 6

Front & Rear Spikes Extended
Cone Extended and Closed

Fig. 7